DOT/FAA/AM-00/13

Office of Aviation Medicine
Washington, D.C. 20591

The Evaluation of In-Flight Medical Care Aboard Selected U.S. Air Carriers: 1996 to 1997

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May 2000

Final Report

This document is available to the public through the National Technical Information Service, Springfield, Virginia 22161.

U.S. Department of Transportation
Federal Aviation Administration

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
DOT/FAA/AM-00/13		

4. Title and Subtitle	5. Report Date
The Evaluation of In-Flight Medical Care Aboard Selected U.S. Air Carriers: 1996 to 1997	May 2000
	6. Performing Organization Code

7. Author(s)	8. Performing Organization Report No.
DeJohn, C.A., Véronneau, S.J.H., Wolbrink, A.M., Larcher, J.G.[1]; Smith, D.W.[2]; and Garrett, J.[3]	

9. Performing Organization Name and Address	10. Work Unit No. (TRAIS)
[1]FAA Civil Aeromedical Institute , P.O. Box 25082, Oklahoma City, OK 73125 [2]University of Oklahoma, Norman, OK 73019 [3]MedAire, Inc., Phoenix, AZ 85006	11. Contract or Grant No. DTFA 02-97P53665

12. Sponsoring Agency name and Address	13. Type of Report and Period Covered
Office of Aviation Medicine Federal Aviation Administration 800 Independence Ave., S.W. Washington, DC 20591	14. Sponsoring Agency Code

15. Supplemental Notes

This work was performed under task AMB-97-TOX-203

16. Abstract

Medical care in-flight and the FAA-mandated medical kit have been studied for many years. This study includes a detailed correlation between in-flight medical care, patient response in-flight, and post-flight follow-up, in an effort to evaluate in-flight medical care delivery on US airlines and re-evaluate the FAA-mandated in-flight medical kit. A survey of five US domestic air carriers from October 1, 1996, to September 30, 1997, showed 1132 in-flight medical incidents. These airlines accounted for approximately 22% of scheduled US domestic enplanements during the period. There was good overall agreement between in-flight and post-flight diagnoses (70% of cases), and passenger condition improved in a majority of cases (60%), suggesting that in-flight diagnoses were generally accurate and treatment was appropriate. Results indicated that bronchodilator inhalers, oral antihistamines, and non-narcotic analgesics, all of which were obtained from other passengers, were used frequently enough to support a suggestion to include them in the medical kit.

17. Key Words	18. Distribution Statement
In-Flight Medical Emergencies, In-Flight Fatalities, In-Flight Medical Care, Medical Flight Diversions, In-Flight Medical Kit	Document is available to the public through the National Technical Information Service, Springfield, Virginia 22161

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	26	

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

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INTRODUCTION

On March 3, 1981, the Public Citizen Health Research Group of the Aviation Consumer Action Project (ACAP) petitioned to amend the Federal Aviation Regulations (FARs) to require the carriage of emergency medical equipment on commercial flights in addition to the FAA required first aid kit. The petition urged that US air carriers be required to have onboard emergency equipment and medication that would enable crew-members and/or medically qualified passengers to respond to any in-flight emergency. On March 14, 1985, the Federal Aviation Administration (FAA) published Notice of Proposed Rulemaking (NPRM) Number 85-9 on emergency medical equipment and on January 6, 1986, published a final rule requiring medical kits on commercial aircraft, although airlines have never been specifically mandated to provide medical attention to passengers (Federal Aviation Administration, 1986).

The FAA-mandated medical kit has been the topic of study for many years (Hordinsky & George, 1991a; Hordinsky & George, 1991b; Thibeault, 1998; DeJohn, Véronneau, and Hordinsky, 1997). A primary question of interest is whether additional items should be included by regulation in the FAA required medical kit. The current medical kit, as mandated under Title 14 of the Code of Federal Regulations (CFR) Part 67, §67.121.309(d) and shown in Table A-1, has a limited number of items. Additional drugs, or drugs with different routes of administration, might be useful in specific incidents. Attitudes toward the medical kit have varied widely and several recent studies have asserted that the FAA mandated in-flight medical kit is inadequate. Speizer, Rennie & Breton (1989) found that none of the 260 passengers arriving at the Los Angeles International airport during a one year period from 1985 to 1986, who developed medical complaints in-flight, benefited from the equipment or drugs available, no deaths were prevented, and the absence of qualified personnel onboard may have rendered any in-flight medical kit useless. In contrast, Cottrell et al. (1989) reported that 26% of 157 health care providers who used the kit in-flight thought that it was very useful, 55% felt that it was somewhat useful, and 18% felt that it was not of any benefit, and Cummins and Schubach (1989) suggested that though the medical kit contained useful items, it was inadequate to deal with several problems that may occur in-flight and suggested several medications be added to the kit to improve it. In addition, Rosenberg and Pak (1997) listed what they broadly classified as mechanical and logistical limitations that made kits inadequate for dealing with emergencies. In their review, they made the observation that in-flight medical problems often require the administration of medications not found in the kit, which frequently may be obtained from other passengers. Also, Prew (1997) went as far as to state that some medical experts believe that without special care, including drugs and a defibrillator, there is not much chance of long-term survival for an in-flight cardiac patient. These studies and significant technical shifts in the last few years suggest that the contents of the medical kit might be re-evaluated and changes considered.

While there have been several studies that have evaluated in-flight medical care aboard commercial airlines (Rodenberg, 1987; Cummins et al., 1988; Speizer, Rennie, & Breton, 1989; Cummins & Schubach, 1989; Cottrell et al., 1989; Hordinsky & George, 1991a; Hordinsky & George, 1991b; Rosenberg & Pak, 1997; DeJohn, Véronneau, & Hordinsky, 1997), they generally did not include a detailed correlation between medical care and patient response in-flight, and post-flight follow-up. The present study attempts to compare patient response to in-flight medical treatment with follow-up information in an effort to evaluate in-flight medical treatment on domestic US air carriers, and the appropriateness of flight diversions for medical reasons.

METHODS

Sources of Data. A survey was undertaken of in-flight medical care aboard domestic US air carriers that contract with MedAire, Inc. for in-flight medical support. MedAire is a private medical service

company that provides in-flight assistance to airlines during medical incidents. Normally this assistance takes the form of a radio patch between the aircraft and a ground-based emergency-room physician who advises the in-flight medical provider on medical treatment decisions, and the aircrew on diversion decisions. Only those incidents that involved an air-to-ground radio patch with MedAire were included in the survey. The survey included five US airlines that contracted with MedAire, and showed there were 1132 in-flight medical incidents from October 1, 1996 to September 30, 1997. These air carriers accounted for approximately 22% of the total number of enplanements for US domestic scheduled air carriers during this period (Austin, 1997).

Nature of the Data. Internal data collection forms were used by MedAire to collect the data at the time of each in-flight event. After the event, a record was completed by the MedAire staff, based on their own experience and the advice of any medical personnel onboard at the time of the incident. The MedAire staff then entered the information from each record into a Microsoft Access® database designed by the FAA Civil Aeromedical Institute (CAMI).

Information provided by MedAire included patient demographics, flight information, flight diversion status, details of the in-flight medical event, outcome, and post-flight discharge diagnosis (List A-1). Most of the information supplied by MedAire was closed-formatted, allowing a specific list of responses; however, some information was open-ended, permitting a wide variation of the entered data. Six areas of primary interest included: patient presentation, in-flight diagnosis, treatment, medical kit items used, outcome, and post-flight discharge diagnosis. All open-ended items were later coded by the CAMI medical staff into fixed categories more suitable to data analysis including patient demographics, flight information, diversion status, in-flight treatment category, CAMI diagnostic category, outcome category, and post-flight discharge diagnostic category (List A-5). Patient demographics included age, gender, and medical history. Flight information included the origin, destination, and type of aircraft. Treatment data, provided in text format, were coded into several categories, including specific medications, patient monitoring, and supportive therapy (List A-4). Similarly, outcome data were coded to reflect what type of post-flight medical treatment facility the patient was transferred to, or whether follow-up treatment was refused or canceled (List A-6). Also, discharge diagnostic category was coded using the post-flight discharge diagnosis data (List A-5). In addition, the patient's demographics, presenting symptoms, in-flight diagnosis, in-flight treatment, response to in-flight treatment, medical kit items used, diversion status of the flight, outcome, and post-flight discharge diagnosis when available, were all considered in coding the CAMI diagnostic category (List A-3).

Data collection was unique in that it involved radio communication between an aircraft in-flight with a physician on the ground. This environment often limits the ability of the ground-based physician to accurately assess and diagnose the airborne emergency situation. The patient can be interviewed and observed with the most rudimentary medical equipment, essentially a stethoscope and sphygmomanometer. Additionally, only a limited choice of treatments are normally available in-flight. Although items used from the medical kit may be supplemented by medications obtained from other passengers, signs and symptoms are likely to be the only reliable information available. As a result, onboard medical conclusions are frequently tentative, and often an accurate diagnosis will not be possible. Consequently, both the in-flight diagnosis and treatment must be viewed with caution and accepted as the best possible conclusions and actions that could be made during an in-flight medical incident. However, the additional quality assurance provided by CAMI physician review allowed for accurate post-flight categorization of cases, which reflected detailed post-flight verification data, including patient outcome, and post-flight discharge diagnosis.

Potential Additions to In-flight Medical Kit (IMK). Frequency tables of usage rates for specific items or categories of items were used to determine potential additions to the medical kit. Items that were frequently obtained from other passengers and used, but not available in the currently mandated medical kit (Table A-2) were primary candidates for additions. The criteria for selection of potential additions to the IMK resulted from a review of the data, which suggested that additional items should be considered for inclusion in the medical kit if: (1) the item was used in more than 2% of all cases, or (2) the item was used in more than 1% of all cases where 1/3 or more of those cases occurred in a single category. For example, diphenhydramine is available in injectable

form in the medical kit but may also be commonly obtained as Benadryl, an oral preparation, from another passenger. Oral Benadryl use was therefore compared to injectable diphenhydramine use to evaluate whether the oral form of the drug should be included in the medical kit. Although an attempt was made to collect data on in-flight medical provider preferences, there were not enough responses from in-flight medical care providers to that item on the questionnaire to properly evaluate the question.

Unfortunately, this approach does not address items that are not included in the medical kit and not routinely carried by passengers, but could have been useful if they had been available to the health care provider in-flight. Such items could not be defined in this study because of insufficient responses to the appropriate question on the questionnaire.

Evaluation of In-flight Medical Care. Other specific analyses included examining the quality of in-flight medical care delivery; patient response to in-flight medical care, including final outcome; and a comparison between in-flight diagnosis and treatment and hospital diagnosis and treatment.

RESULTS

We studied 1132 in-flight medical events which occurred on five US domestic Part 121 air carriers from October 1, 1996 to September 30, 1997. Of the 1125 cases that reported gender, 596 were females and 529 were males. The mean age of the 1057 individuals for whom age was known was 49 years, and the range was seven weeks to 106 years.

Categories of In-flight Medical Events. Each case was assigned a category (List A-3) based on the patient's presenting symptoms, in-flight diagnosis, in-flight treatment, response to in-flight treatment, medical kit items used, the diversion status of the flight, outcome, post-flight discharge diagnosis, and medical history (Table 1). Although vasovagal cases occurred with the greatest frequency, the most common serious categories of in-flight medical events were cardiac (20%), neurological (12%), and respiratory (8%).

Diversions of Flights With In-flight Medical Events. A diversion was defined as a flight that landed at an airport other than the scheduled destination due to an in-flight medical event involving a passenger. Of the 1132 in-flight medical incidents (IMIs), 145 (13%) resulted in an emergency diversion. This represents a diversion rate of about one passenger per one million enplanements.

Category	Frequency	Percent
Vasovagal	254	22.4
Cardiac	221	19.5
Neurological	134	11.8
Respiratory	92	8.1
Gastrointestinal	90	7.7
Trauma	60	5.3
Endocrine	53	4.7
Miscellaneous	52	4.6
Psychological	38	3.4
Vascular	35	3.1
OB/GYN	33	2.9
Allergic Reaction	27	2.4
ENT	20	1.8
Urological	18	1.6
Not Reported	3	0.3
Unknown	2	0.2
Total	**1132**	**100**

Table 1. Categories of In-flight Medical Incidents.

		Diversion		
		Yes	No	Total
Physician Onboard	Yes	70	379	449
	No	75	608	683
	Total	145	987	1132

Table 2. Flight Diversions and Physician Presence.

Of the 449 cases where physicians were onboard, 70 (16%) flights were diverted for medical reasons. In contrast, of the 683 cases where there was no physician onboard, 75 (11%) flights were diverted. A chi-square test performed on the data, which is summarized in Table 2, shows that the presence of a physician was associated with an increase in the percentage of diversions ($\chi^2 = 4.75$, $p < 0.03$).

Category	Category Total	Category Percent	Diversions in Category	Category Diversion Rate (%)	Percent of All Diversions (%)
Cardiac	221	19.5	66	30.0	45.5
OB/GYN	33	2.9	7	21.2	4.8
Neurological	134	11.8	26	19.4	18.0
Vascular	35	3.1	5	14.3	3.4
Endocrine	53	4.7	6	11.3	4.1
Respiratory	92	8.1	9	9.8	6.2
Miscellaneous	52	4.6	5	9.6	3.4
Gastrointestinal	90	8.0	7	7.8	4.8
Psychological	38	3.4	2	5.3	1.4
Vasovagal	254	22.4	10	3.9	6.9
Allergic Reaction	27	2.4	1	3.7	0.7
Trauma	60	5.3	1	1.7	0.7
Total	**1089**	**96.2***	**145**	**N/A**	**100**

* Total does not equal 100% because "Not Reported" and "Unknown" categories are not included.

Table 3. Flight Diversion Frequency by Category.

Table 3 summarizes flight diversions by category. There were no diversions reported for the "ENT," "Urological," "Not Reported," and "Unknown" categories. Cardiac incidents had the greatest percentage of diversions (30%) followed by obstetrical-gynecological incidents (21.2%), and neurological incidents (19.4%).

Frequency of In-flight Medical Kit (IMK) Use. The IMK was used in 533 out of 1132 in-flight medical incidents (47%), it was not used 543 times (48%), and its use status was not reported in 56 cases (5%).

Table 4 shows the relationship between the number of times the IMK was used and whether or not the flight was diverted. Unreported cases are not included in the table; therefore, the total of diversions and non-diversions is not equal to 1132. The kit was used in 82 out of 127 cases (65%) when the flight diverted, and in 451 out of 949 flights (48%) that did not divert. The data, therefore, indicate that there is a greater likelihood that the IMK was used when there was a diversion ($\chi^2 = 12.34$, $n = 1$, $p < .001$).

Overall Patient Response In-flight. The medical condition of passengers improved in 60% of cases, remained the same in 12% of cases, worsened in 2% of cases, and was not reported by MedAire in 26% of cases as indicated in Table 5.

	IMK Used		
Diversion	Yes	No	Total
Yes	82	45	127
No	451	498	949
Total	533	543	1076

Table 4. Flight Diversions by In-flight Medical Kit Use.

Response	Frequency	Percent
Improved	675	60
Unchanged	136	12
Worsened	27	2
Not Reported	294	26
Total	1132	100

Table 5. Overall Patient Response In-flight.

		Patient Improved		
		Yes	**No**	**Total**
Physician Onboard	**Yes**	291	57	**348**
	No	385	106	**491**
	Total	**676**	**163**	**839**

Table 6. Patient Improvement Associated With Physician Presence.

IMK Used			
Patient Response	**Yes**	**No**	**Total**
Improved	349	314	663
Unchanged	73	60	133
Worsened	22	5	27
Total	**444**	**379**	**823**

Table 7. Patient Response Associated With In-flight Medical Kit Use.

Medical Personnel	Frequency	Percent
Physician	449	40
Nurse	278	25
None	249	22
EMT	48	4
Other	47	4
Not Reported	34	3
Paramedic	27	2
Total	**1132**	**100**

Table 8. Medical Personnel Onboard.

Medical Kit User	Onboard	Used Kit	Percent of Time Used
Physician	449	275	61
Nurse	278	190	68
Emergency Medical Technician (EMT)	48	28	58
Other	41	25	61
Paramedic	27	11	41
Physician's Assistant	4	2	50
Nurse Practitioner	1	1	100
Dentist	1	1	100

Table 9. Medical Kit Users.

Of the 348 cases (Table 6) where physicians were onboard and overall patient response was reported, patient condition improved 291 times (84%). By comparison, of the 491 cases where there was no physician onboard and patient response was reported, patient condition improved 385 times, (78%). A chi-square test performed on the data, which is summarized in Table 6, showed that the presence or absence of a physician onboard was unrelated to the number of patients who improved in-flight.

Patient Response Associated With In-flight Medical Kit Use. Table 7 shows that, in general, use of the medical kit was associated with patient response ($\chi^2 = 8.74$, $p = 0.013$). While there was no significant difference in the number of patients who improved in-flight as a result of medical kit use, more patients' conditions worsened with kit use compared to those without kit use ($Z = -0.096$, $p = 0.011$). This association may have been confounded by differences in the severity of the cases and, although statistically significant, may not be of clinical importance.

Medical Personnel Onboard During In-flight Medical Events. Data provided by MedAire (List A-1) indicates physicians were available approximately 40% of the time, nurses 25% of the time, and EMTs 4% of the time as shown in Table 8. "Other" includes physician's assistant, nurse practitioner, dentist, and other individuals who may not have been health care professionals. "None" implies that the medical kit was not used.

Medical Kit Users During In-flight Medical Events. Table 9 shows how frequently each type of medical care provider used the IMK. Cases where the medical kit user was not reported are not shown in the table. It is interesting to note that physicians did not appear to use the kit proportionately more often than other groups of health care professionals.

IMK User	Frequency of Diversions	Percent of Diversions
Physician	43	30
Nurse	28	19
EMT	3	2
Other	8	6
None	45	31
Not Reported	18	12
Total	**145**	**100**

Table 10. Flight Diversions and Medical Kit Users.

Patient Disposition	RMA	Airport	ER	Hospital	Canceled	Not Reported	Un-transported Fatalities	Total
Number of Patients	340	289	196	179	102	17	9	1132
Percent of Patients	30	26	17	15	9	2	1	100

Table 11. Patient Post-flight Disposition.

Diversions and Medical Kit Users During In-flight Medical Events. Physicians used the IMK most often during flights that were diverted (30%), followed by nurses, and EMTs (Table 10). For this analysis, two paramedics were re-categorized and included in the "Other" category resulting in a total of eight flight diversions for that category.

Patient Disposition Following In-flight Medical Events. Many patients who experienced an in-flight medical event refused medical advice (RMA), as shown in Table 11. RMA implies that treatment was indicated but the patient refused further medical treatment following the flight. Of those patients who received medical treatment, most were treated at the airport, either in an airport clinic or by EMTs or paramedics. The next largest group of patients were seen in the emergency room (ER).

Nine out of the 15 fatalities were not transported to a treatment facility and are tabulated separately in Table 11 as "Un-transported Fatalities." The remaining six fatalities were transported to treatment facilities but eventually expired, and they are categorized according to the type of treatment facility involved.

In those cases where further medical assistance at a ground facility was canceled, it was not possible to determine if cancellations were made because the situation changed and the patient no longer required medical attention, or the patient refused further medical support. Of the 102 cancellations for further medical assistance shown in Table 11, 60% were made by the MedAire physician, 33% by the aircrew (usually the captain), 3% by the patient, and 4% of the time it was not known who canceled the response.

Of the 179 patients transported to the hospital, 173 were admitted with an average stay of 2.8 days, although the type of floor or service was known in only ten cases. Of those ten cases, three were admitted to the medical floor, two to the neurological service, two to the obstetrical/gynecological floor, and one to orthopedics.

Specialty Care Unit	Number of Patients	Average Length of Stay (Days)
ICU/CCU	40	3.1
Telemetry	30	2.7
Intermediate	5	2.2
Total	**75**	**2.7**

Table 12. Distribution of Patients in Specialty Care Units.

As shown in Table 12, of the 173 patients admitted to the hospital, 40 were admitted to an intensive/critical care unit (ICU/CCU) with an average length of stay of 3.1 days, while 30 patients were admitted to a telemetry unit for an average of 2.7 days, and 5 patients were sent to an intermediate care unit staying an average of 2.2 days.

Of the 40 patients admitted to an ICU/CCU, 38 were admitted to a medical unit with an average length of stay of three days; one patient was admitted to a cardiac unit for a day, and another was admitted to a surgical unit for a day. Although only one patient was sent to a cardiac intensive care unit, this does not imply that there was only one cardiac intensive care case. Many hospitals do not have separate cardiac or surgical intensive care units; therefore, all serious cases go to a general medical CCU or ICU. When the categories of the 38 patients who were admitted to general ICUs/CCUs were checked, it was discovered that 27 of the patients were diagnosed as cardiac cases in flight. In addition, the one case admitted to the surgical intensive care unit was also diagnosed as a cardiac patient. Consequently, 27 of the 40 patients who were admitted to critical care units were cardiac cases.

Five of the 173 patients admitted to the hospital were sent to intermediate care units with an average length of stay of 2.2 days. Two patients were sent to a general medical intermediate care unit, one patient was sent to a cardiac unit, another to a surgical unit, and one patient was sent to an intermediate care unit where the type of unit was not specified. The average length of stay for the two medical patients was 2.5 days, while the length of stay for the cardiac, surgical, and unknown patients was four days, one day, and one day respectively. While this implies that only one cardiac patient was sent to an intermediate care unit, many hospitals do not have separate cardiac intermediate care units and patients are simply sent to a medical intermediate care unit. When the categories of the two patients admitted to general intermediate care units were checked, it was discovered that one of them was a cardiac case while one was a neurological case; consequently, two of the five patients who were admitted to intermediate care units were actually cardiac cases.

Fatalities Associated With In-flight Medical Events. A fatality was defined as a passenger death that occurred at any time in-flight, during transport to a treatment facility, or at a treatment facility. Fifteen of 1132 cases were fatalities for a case fatality rate of 13.3 per 1000 patients. A summary of the post-flight diagnostic categories for fatalities (CAMI diagnostic categories) is shown in Table 13.

In this, study two fatalities that were initially misclassified as "Respiratory" cases (as shown in parentheses) were later determined to be "Cardiac" deaths when additional information became available from the hospital. In other cases, the status of the patient was unknown at the end of the flight; however, details were subsequently available from the admitting hospital or emergency room.

Potential Additions to the In-flight Medical Kit. A review and analysis of the data suggested criteria for inclusion of additional items in the medical kit: (1) if the item was used in more than 2% of all cases, or (2) if the item was used in more than 1% of all cases where 1/3 or more of those cases occurred in a single category. Table 14 summarizes the items that met either of these criteria.

Oxygen, supportive care (i.e., orange juice, recline, cover with blanket, etc.), close patient monitoring, and analgesics met the first criterion (> 2% of all cases) by wide margins. Nitroglycerin, other than from the medical kit, met both criteria (> 2% of all cases and more than 1/3 of cases in a single category).

Age	Sex	Presentation	Category	Kit User	Diversion	Outcome
61	F	Short of breath and vomiting.	Cardiac (Respiratory)	Nurse	No	Pronounced dead at hospital.
79	F	Passenger expired according to the nurse on board. Pulseless, apneic, pupils fixed and dilated.*	Cardiac	Nurse	No	Pronounced dead at gate.
75	M	Problems breathing, and unconscious.	Cardiac	Physician	No	Pronounced dead at gate.
27	F	Not breathing. CPR was initiated. In cardiac arrest.	Cardiac	Not Reported	Yes	Expired at hospital.
65	M	Pale, not breathing, not moving, cold to the touch.*	Cardiac	Not Reported	No	Pronounced dead at gate.
67	F	Unconscious, unresponsive, unable to find pulse.	Cardiac	None	Yes	Expired at hospital.
71	M	Short of breath.	Cardiac (Respiratory)	None	No	Admitted to hospital; ICU for 3 days & telemetry for 6 days before expiring.
71	M	Difficulty breathing.	Cardiac	None	No	Pronounced dead at gate.
68	M	Difficulty breathing. Respiratory arrest.	Cardiac	Nurse	No	Pronounced dead at gate.
70	F	Respiratory arrest.	Cardiac	None	No	Pronounced dead at gate.
80	M	Syncopal episode in lavatory; vomited and unconscious.	Cardiac	None	No	Expired at unreported time.
32	F	Abdominal pain.	OB/GYN	Other	No	Admitted to hospital where patient later expired.
36	F	Unconscious and not breathing.	Drug Overdose	Paramedic	Yes	Patient expired at hospital.
48	M	Cardiac arrest.*	Cardiac	Physician	No	Patient was later pronounced dead.
40	M	Non-responsive.	Cancer	None	Yes	Transported to hospital where he later expired.

* Indicates cases where information suggests patient may have died on the airplane.

Table 13. Summary of Fatalities

Item	Percent of Total Cases	Category	Category Frequency	Total Frequency
Oxygen	58.2	N/A	N/A	N/A
Supportive care	40.8	N/A	N/A	N/A
Monitor patient	36.1	N/A	N/A	N/A
Analgesic	4.1	N/A	N/A	N/A
Nitroglycerin (not from kit)	3.4	Cardiac	35	38
Bronchodilator inhaler	1.6	Respiratory	14	18
Oral antihistamine	1.0	Allergic reaction	8	11

Table 14. Summary of Response Frequencies for Potential Additions to the Medical Kit.

Item	Worse	Unchanged	Improved
Monitor patient	9 (3.0%)	21 (7.0%)	271 (90.0%)
Nitroglycerin (not from kit)	1 (3.1%)	3 (9.4%)	28 (87.5%)
Bronchodilator Inhaler	1 (6.3%)	1 (6.3%)	14 (87.5%)
Oral Antihistamine	0 (0.0%)	1 (12.5%)	7 (87.5%)
Supportive Care	13 (3.6%)	51 (14.2%)	296 (82.2%)
Oxygen	25 (4.6%)	79 (14.5%)	442 (81.0%)
Analgesic	0 (0.0%)	8 (29.6%)	19 (70.4%)
Mean	**2.9**	**13.4**	**83.7**

Table 15. Effect on Patient Response of Treatments/Potential Additions to the Medical Kit.

A bronchodilator inhaler and an oral antihistamine met the second criterion (> 1% of all cases and more than 1/3 of cases in a single category).

After identifying items that might be considered for inclusion in the medical kit, the impact of these items on patient response to in-flight medical care was investigated. In Table 15, frequencies are shown above, while percentages associated with changes in patient condition are shown below in parentheses. On average, a passenger's condition improved approximately 84% of the time when these measures were employed. Interestingly, close patient monitoring was associated with improvement about 90% of the time. Of those items that could be added to the kit, a bronchodilator inhaler and an oral antihistamine appeared to have the greatest effect on positive patient response to treatment; however, analgesic therapy also showed good results.

Table 16 summarizes cases where bronchodilator therapy was used in-flight, while reflecting whether oxygen was used, and the passenger's response to the treatment.

Bronchodilator Therapy Cases			
Oxygen Used	**Worsened**	**Unchanged**	**Improved**
Yes	1	1	12
No	-	-	2

Table 16. Oxygen Use in Bronchodilator Therapy.

Post-flight Diagnostic Category	In-flight Diagnostic Category													
	Cardiac (70)	Trauma (22)	Vasovagal (32)	Respiratory (20)	Misc. (15)	GI (15)	Neurological (22)	Vascular (12)	OB/GYN (8)	Endocrine (8)	ENT (5)	Allergic Reaction (4)	Psychological (3)	Urological (3)
Cardiac (62)	57	0	4	0	0	0	0	0	0	1	0	0	0	0
Trauma (22)	0	22	0	0	0	0	0	0	0	0	0	0	0	0
Vasovagal (29)	5	0	22	1	0	0	1	0	0	0	0	0	0	0
Respiratory (20)	0	0	1	18	1	0	0	0	0	0	0	0	0	0
Misc. (22)	2	0	1	1	12	3	3	0	0	0	0	0	0	0
GI (14)	1	0	0	0	0	11	1	0	1	0	0	0	0	0
Neurological (10)	0	0	0	0	0	0	9	1	0	0	0	0	0	0
Vascular (23)	3	0	3	0	1	1	5	9	0	1	0	0	0	0
OB/GYN (8)	0	0	0	0	1	0	0	0	7	0	0	0	0	0
Endocrine (10)	0	0	1	0	0	0	2	1	0	6	0	0	0	0
ENT (5)	0	0	0	0	0	0	0	0	0	0	5	0	0	0
Allergic (4) Reaction	0	0	0	0	0	0	0	0	0	0	0	4	0	0
Psychological (6)	2	0	0	0	0	0	1	0	0	0	0	0	3	0
Urological (4)	0	0	0	0	0	0	0	1	0	0	0	0	0	3

Table 17. Comparison of In-flight and Post-flight Diagnostic Categories.

The overwhelming majority of patients who received both bronchodilator and oxygen therapy improved; however, there were not enough cases that did not receive oxygen therapy in conjunction with bronchodilator therapy to allow a proper comparative analysis. In fact, the two cases that did not receive oxygen with a bronchodilator improved.

Comparison of In-flight and Hospital Discharge Diagnostic Categories. Post-flight diagnostic categories were obtained from patients who were seen in the emergency room, airport clinic, or hospital. Post-flight diagnostic categories were known in 239 out of 1132 cases, or approximately 21% of the time. Those cases where in-flight diagnostic category and post-flight discharge diagnostic category were known are compared in Table 17. Cases classified as "Unknown" were not included in the comparison. In-flight diagnostic categories are shown as columns, while post-flight diagnostic categories are shown as rows. The figure in parentheses next to each category indicates the number of cases in that category. All cases where in-flight diagnostic category agrees with post-flight diagnostic category appear on the diagonal in the table. In-flight and post-flight diagnostic categories agreed in 188 out of 239 cases (79%). Accepting post-flight diagnoses as accurate, further comparisons are possible. For example, while 70 patients were assigned a cardiac diagnostic category in-flight, only 62 were similarly classified on discharge from the hospital, with agreement in 57 cases. There are two ways that the in-flight category can disagree with the post-flight category: (1) a cardiac category could be assigned in-flight and a non-cardiac category can be assigned post-flight (i.e., over-diagnosis in-flight), or (2) a non-cardiac category could be assigned in-flight where a cardiac category is assigned post-flight (i.e., under-diagnosis in-flight). Examination of the cardiac column (in-flight diagnostic category) in Table 17 reveals that 16 patients were assigned a cardiac diagnosis in-flight, and were later assigned a non-cardiac diagnosis at hospital discharge, implying that these patients might have been over-diagnosed as cardiac patients in-flight. Looking at the cardiac row (post-flight diagnostic category) in Table 17 shows that five patients who were diagnosed as non-cardiac in-flight, were eventually classified as cardiac cases post-flight, suggesting that these patients might have been under-diagnosed as cardiac patients in-flight.

A comparison of in-flight and post-flight diagnoses for cardiac cases is shown in Table 18. A Chi-square analysis of these data shows that there was general agreement between in-flight diagnostic categories and post-flight discharge diagnostic categories ($\chi^2 = 154.6$, $n = 1$, $p < .001$).

Next, a post-hoc analysis was performed using a McNemar test on the data to determine if cardiac patients were over-diagnosed or under-diagnosed in-flight. The results suggests that cardiac patients were neither under- nor over-identified in-flight.

Similarly it can be demonstrated that non-neurological cases were over-identified as neurological in-flight ($\chi^2 = 8.6$, $n = 1$, $p < .003$) while vascular incidents were under-diagnosed in-flight and attributed to other causes ($\chi^2 = 5.9$, $n = 1$, $p < .01$). Of the 14 vascular cases, five were diagnosed in-flight as neurological cases, three as cardiac, three as vasovagal, one as gastrointestinal, one as endocrine, and one as miscellaneous. Of the 13 non-neurological cases that were diagnosed as neurological cases in-flight, two were later determined to be endocrine, one was later diagnosed as gastrointestinal, one as psychological, five as vascular, one as vasovagal, and three as miscellaneous.

	Post-flight Discharge Category		
In-flight Category	**Cardiac**	**Non-cardiac**	**Total**
Cardiac	57	13	70
Non-cardiac	5	157	162
Total	62	170	232

Table 18. Comparison of In-flight and Post-Flight Diagnoses for Cardiac Cases.

Category	Agreement Rate (%)
Cardiac	92.2
Trauma	100.0
Vasovagal	92.9
Respiratory	98.3
Miscellaneous	94.6
GI	97.1
Neurological	94.1
Vascular	92.9
OB/GYN	99.2
Endocrine	97.5
ENT	100.0
Allergic Reaction	100.0
Psychological	98.7
Urological	99.6

Table 19. Comparison of In-flight and Hospital Diagnoses for all Categories.

An agreement rate of 92.2% was calculated for cardiac cases by summing the total cases where in-flight and post-flight diagnoses agreed (57 cardiac plus 157 non-cardiac) and dividing by the total number of cases (232). Agreement rates for the other categories are summarized in Table 19.

DISCUSSION

Limitations of the Study. The experience of airlines that contract with MedAire for support during in-flight medical emergencies may not be representative of the entire airline industry. First, many of the more serious incidents may be reported on contracting airlines simply because a consistent approach to their management is available. Second, the management of in-flight medical incidents may differ from the management of incidents on other airlines. For example, because knowledgeable emergency medical staff are involved, the number of flight diversions for medical reasons may decrease. Although conclusions about the value of specific medical equipment or supplies can be made about incidents managed under the auspices of MedAire, the application of those conclusions to the airline industry in general may not be appropriate. Essentially, any conclusions about the larger population of medical incidents are somewhat speculative.

Frequency of In-flight Medical Events. We analyzed 1132 in-flight medical incidents that occurred aboard five US domestic airlines from October 1, 1996 to September 30, 1997. These airlines carried approximately 1.4 million passengers during that time; therefore, our in-flight medical incident rate was about 8 per million enplanements. This rate is low compared with rates found in earlier studies. For example, a 1996 Air Transport Association survey yielded 17 incidents per million enplanements (Air Transport Association, 1998), while a British Airways study found 31 incidents per million enplanements (Harding & Mills, 1993), and a Qantas study reported 48 incidents per million enplanements (Davis & Degotardi, 1982). Differences between this study and similar studies are probably due to the different methodologies employed. Only those incidents that involved an air-to-ground radio patch are included in the MedAire data. Minor in-flight medical incidents, that would have presumably been included in the other studies, would not have been included in this study because they would not have required an air-to-ground patch.

Categories of In-flight Medical Events. The six most common causes of in-flight medical events were vasovagal, cardiac, neurological, respiratory, gastrointestinal, and trauma. Category frequencies in similar studies vary widely as shown in Table 20.

Differences in data collection methods and classification schemes employed in the various studies make meaningful comparison between studies difficult. For example, some studies were limited to a single airline and included only cases where the in-flight medical kit was opened and a medical record form, contained in the kit, was completed (Cottrell et al., 1989). Other studies limited data collection to passengers arriving at a single airport (Cummins & Schubach, 1989; Speizer, Rennie & Breton, 1989). In addition, the categorization of in-flight events varied from one study to another. As an example, some studies clearly defined cases as "vasovagal syncope" (Harding & Mills, 1993), while others were not as clear as to what was included in the classification of "syncope" (Cummins & Schubach, 1989).

Diversions of Flights With In-flight Medical Events. Diversions for medical reasons occurred for only one in one million passengers. The same rate has been found in earlier studies (Cummins & Schubach, 1989; Schoken & Lederer, 1970), indicating that despite advances in medicine over the years, the

Common Causes of In-flight Medical Incidents (Percent of Total Incidents)							
	CAMI/ MedAire (N=1132)	Donaldson & Pearn (1996) (N=454)	Cummins & Schubach (1989)[1] (N=1107)	Davies & Degotardi (1982)[2] (N=45)	Speizer et al. (1989) (N=260)[3]	Cottrell Et al. (1989) (N=362)	Harding & Mills (1993)[5] (N=2139)
Vasovagal	22	35	4	10	6	29	20
Cardiac	20	16	20	29	20	16	3
Neurological	12	4	8	4	4	4	0[3]
Respiratory	8	6	8	2	9	10	5
Gastrointestinal	8	13	15	6	12	0[4]	12
Trauma	5	4	14	7	6	0[4]	0[4]

[1]In-flight cases only.
[2]Physician reported incidents only.
[3]Includes only the 123 cases where emergency department diagnosis was given.
[4]Category was not listed among the six most common in this study.
[5]Data from April 1990 to March 1991 British Airways study.

Table 20. Common Causes of In-flight Medical Incidents.

introduction of the in-flight medical kit in 1986, and the more recent incorporation of in-flight telemedicine, the diversion rate for medical reasons has remained small but constant.

Although most operations that occur on a "once-in-a-million" basis can generally be considered an acceptable risk, there are two reasons that medical diversions are important: (1) they are time consuming and expensive events, and (2) many of them can be avoided. Diversions can affect the schedules of large numbers of passengers who require accommodation and possible financial compensation for their inconvenience. As an example, diversions cost British Airways up to £500,000 ($893,000 US) in 1996 (Kahn, 1996). In addition, a series of time-consuming steps must be taken for any diversion to take place. Not only must arrangements be made to receive and transport the ill passenger on landing, but the available medical facilities at a potential alternate destination must be considered. It would be unwise to divert to another airport and determine too late that ground transportation is not available for the patient, or that the local medical facility cannot provide the care required for the patient's condition. Also, the pilot, along with flight dispatch, must determine a suitable landing airport, which may or may not be serviced by the company or be familiar to the flight crew. Landing weight is also a consideration, and valuable fuel may have to be jettisoned to attain a suitable landing weight for a premature touch-down.

Consequently, methods of avoiding flight diversions are constantly being sought. Three possibilities include: (1) the presence of an onboard physician, (2) passenger education, and (3) medical kit improvements. However, results showed that physicians were onboard only 40% of the time and were associated with the highest diversion rate among in-flight medical care providers. Educating travelers about the nature of the aircraft cabin environment has been suggested, since many passengers believe that cabin pressure is the same as sea level and know very little about hypoxia, dehydration, or the heightened effects of medication or alcohol at altitude (Kahn, 1996). Assertions that the kits were inadequate for dealing with in-flight emergencies (Rosenberg & Pak, 1997), passengers did not benefit from the equipment or drugs available (Speizer, Rennie, & Breton, 1989), and no deaths were prevented (Speizer, Rennie, & Breton, 1989), have led researchers to suggest several improvements (Thibeault, 1998).

Approximately 28 out of the 145 (19%), of the flight diversions in this study were probably unnecessary in light of subsequent follow-up information. In three of the 28 cases (two cardiac cases and one

respiratory case) the passengers refused further medical advice; therefore, there was no post-flight follow-up. The remaining 25 cases did not appear to be serious enough to have warranted a flight diversion for medical reasons, according to post-flight treatment facility discharge information. Of the 25 cases, nine were eventually diagnosed as vasovagal syncope, five as dehydration, four as gastroenteritis, two as viral infections, two as non-cardiac chest pain, one as anxiety, one as false labor, and one as sickle cell anemia. However, it must be emphasized that these determinations were arrived at after careful consideration of post-flight treatment data that were not available during the flight. Earlier studies reported an even higher percentage of unnecessary diversions. In their study, Schoken and Lederer (1970) estimated that about half of the unscheduled landings could have been avoided, while Cummins and Schubach (1989) stated that all seven of the unscheduled landings in their study were probably unnecessary.

Diversion Categories for In-flight Medical Events. It is interesting to note that those categories of in-flight medical events that occurred with the highest frequency did not necessarily account for the greatest number of flight diversions. As an example, while vasovagal incidents represented the greatest number of cases, the percentage of diversions for that category was low compared with other, more serious, categories. Other studies showed similar results. The three categories that accounted for the most diversions in this study were cardiac, neurological, and vasovagal, while a 1970 American Airlines study (Schoken & Lederer) listed the three most common reasons as syncope, heart attack, and dyspnea.

Diversions and Medical Kit Use. In this study there was a proportionately greater likelihood that the IMK was used when there was a flight diversion. Although this association is statistically significant, it is probably confounded by differences in severity between categories. This may be because the medical kit is used more frequently in severe incidents, which are more likely to result in a diversion; whereas, minor incidents, which are less likely to cause the kit to be used, are also less likely to result in a diversion.

Overall Patient Response In-flight . It is encouraging to note that in over half of the cases in our study, passenger condition improved, whereas passenger condition worsened in only a few cases. Although patient condition improved most of the time when there was a physician onboard, it was not significantly different from when a physician was not present. It is also possible that the 26% of unreported cases were of a less serious nature, whereas the more serious cases were followed-up and reported on. This would imply that more patients might have actually improved than are indicated by the data. These data suggest that even under the difficult conditions encountered in-flight, diagnoses and treatment of passengers appears to be appropriate most of the time, whether or not a physician is aboard. These data are more encouraging than the 32% improvement rate reported by Cottrell et al. (1989).

Patient Response Associated With In-flight Medical Kit Use. Our results showed that medical kit use appeared to have an inverse relationship on patient response; that is, kit use was associated with worsening patient condition. While these results appear to be illogical, they are not, because the data are not the result of a repeated measures experiment. The patients in the three categories (worsened, unchanged, and improved) were different; therefore, the severity of each case was a confounding variable. It is possible that those patients whose condition improved had less severe medical conditions that improved without kit use, while patients whose condition worsened may have had more severe medical conditions that would have become worse with or without kit use. It is also interesting to note that, while 60% of patients improved overall in-flight, as shown in Table 5, only 31% of patients improved when the IMK was used as shown in Table 7. This is probably because the medical kit was used for more serious cases and was not required for less severe cases. Stated differently, those cases that involved medical kit use also involved the more seriously ill passengers who were less likely to improve in-flight.

Medical Personnel Onboard and Medical Kit User. While physicians identified themselves in-flight approximately 40% of the time, they were the medical provider over half the time when the IMK was used. In other studies, the availability of physicians during in-flight medical events has been shown to vary widely, from about 8% to approximately 85% (Mills & Harding, 1983; Speizer, Rennie & Breton, 1989; Cummins et al., 1988; Cottrell et al., 1989; and Hordinsky & George, 1991b). It is not clear, however, whether physicians were actually onboard more often but simply did not identify themselves. For example, one study reported that at least one half of physicians surveyed stated they were reluctant to

respond, usually because the problem would be outside their field of practice, or because they believed they would be greatly hampered in conducting treatment on an aircraft (Hays, 1977).

Diversions and Medical Kit User. The results imply that when the kit is not used ("None" in Table 10), flight diversions occur less frequently. Again, this may be because when the medical kit is not used, the incident may not be as serious, and a diversion will be less likely.

While EMTs experienced the lowest percentage of diversions among identifiable medical provider groups responsible for diversions (2%), physicians had the highest (30%). The higher proportion of diversions for physicians might have resulted for a number of reasons. Physicians would normally be expected to take charge during the most serious in-flight events that would ordinarily require a flight diversion. Also, when they did suggested that a flight should divert, their medical opinion may have weighed more heavily with the flight crew and the MedAire physician than when less highly trained health care professionals made the same suggestion under similar circumstances. Some of the groups were represented by such low frequencies, however, that small changes in the number of cases could have produced large changes in the percentage of diversions for that group, preventing meaningful analysis.

Patient Disposition Following In-flight Medical Events. Out of 1,119 passengers who experienced an in-flight medical event with a known outcome, 345 (31%) refused medical advice (RMA). This proportion is much greater than a 1989 study by Cummins and Schubach which found that only 1% of passengers with in-flight emergencies declined recommended advice.

A cancellation implied that either the medical situation changed and treatment was no longer indicated, or the patient declined further medical treatment. Although it appears that few treatment cancellations were made by the patient, there is no way of determining how many cancellations may have originated with the patient and been relayed by the aircrew. Cancellations made by the aircrew or patient imply that a physician may not have been involved in the decision. Fortunately, the MedAire physician was responsible for the majority of cancellations, which is the best situation, as it reflects a decision made by a medical professional in possession of the best available information.

One hundred seventy-three patients were admitted to the hospital during the study, with an average length of stay of 2.8, days compared with the national average of 5.2 days for the same period (Centers for Disease Control, 1999). The service to which they were admitted was known in only 10 of the 173 cases; therefore, meaningful conclusions could not be drawn.

Fatalities Associated With In-flight Medical Events. There were 15 fatalities during the one-year period of the study for a case fatality rate of 13.3 per 1000 patients. The mean age for fatalities was 59.3 years and the range was 32 to 80 years.

Officially, none of the 15 fatalities expired on the aircraft. They were either pronounced dead at the gate or at the hospital. However, information on three of the patients suggests that they may have died on the aircraft (cases indicated with an asterisk in Table 13). This implies that more passengers may die onboard airplanes than are reported each year.

The fatality rate was 0.107 fatalities per million enplanements. This rate is about one-third of that found in similar studies. Of the 120 International Air Transport Association (IATA) member airlines, 42 airlines reported a total of 577 in-flight deaths between 1977 and 1984 averaging 0.31 fatalities per million enplanements (Airline Transport Association, 1998). A 1996 Qantas study reported a fatality rate of 0.38 per million enplanements (Donaldson & Pern, 1996). The comparatively lower in-flight death rate in this study might be due to two factors: (1) the data were limited to US domestic flights that might have been able to divert in less time than many of the IATA or Qantas flights, which were mostly international flights, and (2) all MedAire flights were managed by an air-to-ground radio patch with an emergency room physician, which should have resulted in an improved outcome.

The Airline Transport Association (ATA) reported 42 in-flight deaths in 1996 (Airline Transport Association, 1998). Adjusting for the size of the ATA sample, which represented approximately 90% of US domestic enplanements for that year, yields an industry-wide in-flight death rate of approximately 47 fatalities per year. Assuming the experience of the five MedAire companies in this study could reasonably be considered representative of the airline industry at large, and adjusting for sample size, an industry-wide rate of approximately 75 in-flight fatalities per year is derived. The disparity in the number of deaths between the two studies is probably due to reporting

differences. The ATA study only accounted for individuals who were pronounced dead on the aircraft or on the jetway while, in the current study, individuals who were pronounced dead in-flight and post-flight at the gate, in transit, or at the hospital were included. In fact, only three cases would probably have been reported as fatalities in the current study if data collection had been limited to individuals who expired aboard the aircraft. The other twelve cases were determined from information collected during follow-up.

Only four out of the 15 fatal cases were diverted implying a flight diversion rate for fatalities of 27%. In a similar study Cummins (Cummins et al. 1988) found a diversion rate for in-flight fatalities of only 14%, citing the unavailability of diversion locations on international flights as a possible explanation. This unavailability could account for the difference in rates, as all flights in this study were US domestic flights with many suitable diversion locations available. It may not be unusual that 11 out of 15 fatal cases were not diverted. Although each patient was officially pronounced dead at the gate or at a later time, it appears that at least some may have actually expired onboard the aircraft, and a diversion might not have been indicated in these cases. In other cases, the destination may have been as close as any suitable diversion location, or the medical facilities at the destination may have been better than those available at a diversion city.

The most common cause of death in-flight was cardiac (12 of 15, or 80%), followed by pre-existing medical conditions (2 of 15, or 13%). Cummins (Cummins et al. 1988) also found cardiac deaths to be the most common (56%), followed by deaths due to pre-existing medical conditions (19%), while a Qantas Airlines study (Davies & Degotardi, 1982) listed myocardial infarction as the leading cause of in-flight death (11 of 25, or 44%), followed by cerebral vascular accident (2 of 25, or 8%).

Potential Additions to the Medical Kit. Our study indicated bronchodilator inhalers, oral antihistamines, and non-narcotic analgesics were used frequently enough to suggest including them in the medical kit to deal with several common in-flight medical events. While Cotrell et al. (1989) also concluded that a bronchodilator inhaler should be added to the medical kit, Thibeault (1998) suggested the addition of a bronchodilator inhaler, an antihistamine, and an analgesic, among other items.

In addition, oxygen, supportive care, and close patient monitoring were associated with an improvement in patient condition. Good medical practice should include oxygen therapy when a bronchodilator is used, especially given the mildly hypoxic cabin environment. For example, the oxygen saturation of a normal individual at a cabin altitude of approximately 8000 feet is about 85%. While the majority of patients who received both bronchodilator and oxygen therapy improved, there were not enough cases that did not receive oxygen with bronchodilator therapy to analyze.

Comparison of In-flight and Hospital Discharge Diagnostic Categories. There was good overall agreement between in-flight and post-flight diagnostic categories. This agreement suggests that in-flight diagnoses were generally accurate, even under the difficult conditions encountered onboard aircraft. However, the data suggest that non-neurological cases were over-diagnosed as neurological cases in-flight, and vascular cases appeared to have been under-diagnosed and attributed to other causes in-flight.

Severity of In-flight Medical Events. As was previously discussed, there was no independent means of determining the severity of cases. Unless patients can successfully be grouped by severity, it may not be possible to completely evaluate in-flight medical care delivery, or understand the role of medical kit use, patient response, diversions, or other important questions. At this point, it can only be said that in-flight medical care and medical kit use have a significant relationship to patient response that appears to be confounded by the severity of the event.

CONCLUSIONS

Data collection was limited to airlines contracting with MedAire, Inc. and may not be representative of medical incidents occurring on other airlines. While conclusions about the airline industry in general are speculative, this study contains valuable data because it represents a systematic attempt to follow patients from the air transport system into the healthcare system.

The frequency of in-flight medical incidents was low when compared with similar studies; however, the true rate may actually have been greater because cases not serious enough to warrant an air-to-ground radio patch were not included. Cardiac events were the most common serious in-flight medical incidents and accounted for the greatest percentage of aircraft diversions for medical reasons.

Although the fatality rate included passengers who expired after removal from the aircraft, cases were limited to domestic flights that were managed by air-to-ground communication with a physician, which could explain the lower fatality rate found in this study compared to earlier studies; however, the rate would have been even lower if only passengers that died onboard were included. In addition, the diversion rate for fatalities is about double the rate for non-fatal events, probably because fatal cases were generally more serious and required a flight diversion more often than non-fatal cases.

In-flight diagnoses were in close agreement with hospital discharge diagnoses, and patients' conditions generally improved, implying that in-flight medical care delivery aboard US domestic air carriers is generally well managed. However, there did not appear to be a significant difference between patient improvement and the presence or absence of a physician onboard.

The data suggest that oxygen, supportive care, and close patient monitoring were associated with an improvement in patient condition. The data also support the addition of a non-narcotic oral analgesic, a bronchodilator inhaler, and an oral antihistamine to the medical kit. These items have been recommended in other studies and are currently carried by several international air carriers. Unfortunately, due to the poor response to certain questions by onboard care givers, this survey could not address potential medical kit items that are frequently needed for relatively common conditions but are rarely available because they are not routinely carried by other passengers.

RECOMMENDATIONS

Using the criteria adopted in this study, the items that should be considered for possible addition to a future medical kit include a non-narcotic oral analgesic, a bronchodilator inhaler, and an oral antihistamine. Since these data were collected from airlines that did not have cardiac defibrillators onboard, no recommendations are presented regarding the value of adding cardiac medications to the kit that could be used to support an onboard defibrillator. The in-flight medical kit should be re-evaluated once defibrillators become widely available on US domestic air carriers to determine additions to the kit that would be appropriate to support the use of automatic external defibrillators.

If the impact of in-flight medical care delivery and medical kit use is to be fully analyzed, it may be necessary to design a voluntary study to include a larger segment of the air transport industry. One method of facilitating data collection might be to include an event reporting form in the medical kit, to be completed at the time of the incident. If this is not possible, mandatory reporting might be necessary; however, our experience (DeJohn, Véronneau, & Hordinsky, 1997), is that voluntary cooperation is superior to mandatory reporting and yields better results.

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APPENDIX A

Kit Item	Frequency	Percent
Sphygmomanometer	522	46.1
Stethoscope	518	45.8
Nitroglycerin	45	4.0
Syringes and needles	17	1.5
Diphenhydramine	9	0.8
Epinephrine	8	0.7
Dextrose	4	0.4
Airways	0	0.0

Table A-1. Frequency of Use of Medical Kit Items for Five Air Carriers Over a 12 Month Period.

Item	Frequency	Percent
Oxygen	659	58.2
Supportive therapy	462	40.8
Monitor	409	36.1
Analgesic	46	4.1
Nitroglycerin	38	3.4
Bronchodilator inhaler	18	1.6
Oral antihistamine	11	1.0
Anti-acid	9	0.8
Other	7	0.6
Anti-coagulant	6	0.5
Narcotic analgesic	5	0.4
Benzodiazepines	4	0.4
Hyperglycemic	3	0.3
Hypoglycemic	3	0.3
Anti-emetic	2	0.2
Diuretic	2	0.2
Anti-arrhythmic	1	0.1
Topical antihistamine	1	0.1
Vasodilator, other	1	0.1

Table A-2. Frequency of Use for Medical Items not in Kits.

List A-1. Information Provided by MedAire

Radio patch number
Date of event
Aircraft type
Origin
Destination
Company station (Whether the diversion airport had facilities operated by the airline.)
Age of patient
Gender of patient
Presentation (Signs and symptoms.)
In-flight diagnosis
Medical history
Medication history
In-flight treatment
Medical personnel on board
In-flight medical kit use (Whether or not the in-flight medical kit was used.)
In-flight medical kit user
In-flight medical kit items used
Respirations
Pulse
Blood pressure
Items that could have been used but were not available in the in-flight medical kit
Recommendations for medical kit changes
Overall patient response in-flight
Category of medical response waiting at gate (i.e., ACLS, BLS, etc.)
Patient response to medical care at gate
Outcome
Narrative
Discharge diagnosis
Diversion (Whether the flight diverted and diversion airport.)
Diversion status (Whether or not the diversion was coordinated by MedAire.).

List A-2. Data Coded by CAMI

Gender
Patient presentation
In-flight diagnosis
In-flight diagnostic category
Treatment
In-flight medical kit usage
In-flight medical kit items used
Diversion
Outcome
Discharge diagnostic category
Agreement between in-flight diagnostic category and discharge diagnostic category

List A-3. CAMI Diagnostic Code Categories

Allergic reaction
Cardiac
Endocrine
Ear-nose-throat (ENT)
Gastrointestinal
Neurological
Obstetrical/gynecological (Ob-Gyn)
Psychological
Respiratory
Trauma
Urological
Vascular
Vasovagal
Miscellaneous
Unknown

List A-4. Treatment Code Categories

Analgesic
Anti-acid
Antiarrhythmic
Anticoagulant
Antiemetic
Benzodiazepine
Bronchodilator inhaler
Diuretic
Hyperglycemic
Hypoglycemic
Monitor
Narcotic analgesic
Oral antihistamine
Oxygen
Supportive therapy
Topical antihistamine
Vasodilator
Other
Not reported

List A-5. Discharge Diagnostic Code Categories

Allergic reaction
Cardiac
Endocrine
ENT
Gastrointestinal
Miscellaneous
Neurological
Not applicable
Not reported
Obstetrical/Gynecological
Psychological
Respiratory
Trauma
Unknown
Urological
Vascular
Vasovagal

List A-6. Outcome Code Categories

Admitted to hospital
Days in hospital
Admitted to intensive/critical care unit
Days in intensive/critical care unit
Type of intensive care unit
Days in intermediate care unit
Type of intermediate care unit
Admitted to floor/service
Days on floor/service
Floor service admitted to
Admitted to telemetry unit
Days in telemetry unit
Treated and released in airport clinic
Treated and released from emergency room
Medical response canceled
Who canceled medical response
Refused medical advice
Fatality
Where pronounced
Miscellaneous
Not reported